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Toward Transit Metropolis: Status Quo Analysis for Chinese Major Cities

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Abstract

In order to promote low-carbon transport, "The 12th five-year Transport Development Planning" released by the Ministry of Transport (MoT) of P. R. China in 2011, indicates that MoT will provide significant funds to support 30 cities to build "The Transit Metropolis" before 2015. In order to support the “Transit Metropolis” project, the authors led great efforts on collecting statistic and economy data, geography and population data, transportation infrastructure and operation data, transit passenger degree of satisfaction data, etc. Based on all the ground information, this paper assessed the status of urban public transit in China, and analyzed the factors that affect the public transit development. It is found that the relationship between the transit mode share and the GDP per capita follows a “flash” shape and can be divided into three phases. With the growth of GDP, the trend of the transit mode share typically goes “up-down-up” due to the different stages of economy level, car ownership and investment on transit system. Based on the analysis and discussion, some suggestions are provided to develop a hierarchical multi-modal transit system with smooth transfers and good coverage to mitigate traffic congestion and improve the sustainability of urban transportation system in China.

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Keywords: Public transit; Mode share; Transit net length; Transit development

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1. Introduction

Currently, series of traffic problems have become a key factor that slows down the urban development in China, along with the rapid growth of urbanization and motorization. The construction of additional urban roads is limited by land resource, forming a growing gap between the supply of roads and traffic demands. There are various imbalances between economy, population, motor vehicles, and urban-transport capacity. Congestion is the direct manifestation of the imbalance. Beijing has been rated the city with the worst traffic congestion problem worldwide by American media in 2010. The annual direct and indirect economic loss of the multi-million-population sized metropolises in caused by congestion can reach up to 160 billion Yuan. Horrendous traffic fails to keep up the pace of development. In the future, Woetzel, J (2009) said, with the current unprecedented pace of China's urbanization trends, China will have 221 cities with one million–plus inhabitants and 23 cities with more than five millions by 2025 (1). Given this, there would be increasing huge traffic pressures and problems, thus we should find effective way to relieve these problems.

Public transport is an important part of the urban transport. Comparing with private cars, urban public transit stands out in the areas occupied, energy consumption, efficiency, and chemical noxious gases emission. Approximately, public transit takes 10% of the road resources taken by private cars, when delivering the same amount of passengers. The amount of energy consumed and gases emission caused by public transit are 80% less than those of private cars. The statistics show that public transit is an effective way to contribute to the low-carbon and sustainable urban development. Thus, to relieve traffic congestion, pollution, traffic noise, energy consumption, and traffic accidents, public transit is promising way to reduce the private car usage and improve urban transport efficiency.

Since the beginning of the 21st Century, China has been making great efforts to promote public transit system. By the end of 2009, the total length of public transit lines has reached 289,000 kilometers, while the total length of bus lane has reached 7,452 kilometers; urban rail transit has been operating or under construction at 12 cities, including Beijing, Shanghai, Hong Kong, and Xi’an, with a total operating mileage 1,556.2 kilometers; the Bus Rapid Transit (BRT) system has been introduced to over 10 cities. The total amount of passenger of public transit reached 77.9 billion, among which 74.3 billion were from bus transit, and 3.6 billion from rail transit. (the data here is from the Statistical Yearbook of China, 2011)

The urban public transit in China is developing rapidly, but it is at the beginning stage comparing with the systems in the developed countries. Xuying Guo (2008) mentioned, in China, national urban public transit investment is 1% of GDP in 2006, far less than that of cities in developed countries which maintains a share of GDP from 3% to 5% (2). Faced with the high-speed urbanization process, the Chinese government has made a decision to enlarge the investment in public transit systems to promote the construction of public transit system.

Recent, the Chinese government has made a series of policies to the development of public transit. According to the “12th Five-Year Development Plan for Transportation” issued by the Ministry of Transport (MoT), 30 cities will be chosen to launched the Project of Transit Metropolis before 2015.

The goal of the Project of Transit Metropolis is to build more complete public transit systems to become the mainstay of the urban transport system. MoT proposes a series of indicators to evaluate the public transit level of a city and provides suggested values of these indicators for transit metropolis, for example, public transit sharing rate more than 40%~50%, the coverage rate of the 500-meter transit stop above 95%, transfer times for each trip no more than 2, the average transfer times less than 0.5, the average bus running speed above 20 km/h, and so on. Cities, qualified with urban population more than 1.5 million and completed transit planning such as "the urban public transit development programming", will be candidates to be transit metropolis. Specific measures and policies are expected be applied in Transit Metropolis. For instance, public transit will be considered as the first factor that affect the distribution of industry, or Bus Rapid Transit (BRT) corridor will lead the distribution of residential areas. While promoting public transit development, the transit metropolis should control the growth of private vehicles by utilizing Travel Demand Managements measures, as well as realize the sustainable urban development.

The aim of this paper is to assist Chinese central government and Chinese major cities to understand development features and the current development level of public transit by horizontal comparison within some cities of China, and help to form practical plans by referring to the strategies and policies. The paper conducted a general analysis on the urban public transit in China. In the third part the paper summarized the development features of the public transit in China in different levels. In the last part the authors offered suggestions on developing public transit.

In the paper the authors made lateral comparison on the current development of urban public transit in different cities of China. The development status refers to the amount and results of the investment made to the public transit. The authors focused on conducting phase analysis on cities of different development phases, and do not make longitudinal analysis in accordance with time.

Some studies have proved that the factors that have definite influence on the transit ridership are the economy situation, the size of the city, and population. Brian D. Taylor and Camille N.Y. Fink (2003) divided the elements into two categories, external and internal factors. Service area population and employment belong to external factors which are exogenous to the transit system and its managers and can affect transit demand. Fares and service levels belong to the internal factors that can be controlled by transit managers. Economic factors explain substantial portions of transit use. Spatial factors explain much variation in transit ridership (3). Brian D. Taylor (2009) addressed the simultaneous relationship between transit service supply and transit patronage demand, finding that most of the variation in transit ridership among urbanized areas can be explained by factors outside of the control of public transit systems(4). According to explain structure model, Sun Hui (2010) divided the factors into three levels based on the level of impact (5). The first level (the leading level) is the urban economic status, the size of city, and population; The second level is policies, the form of cities and land usage, characteristics of travelers and travel demands, map of public transit, fare, and the service level of public transit (these factors are closely related to each other and requires quantitative analysis); the third level is the accessibility to the public transit information. Dong Zhang and Xiaoguang Yang (2012) developed three models, estimated and compared with each other to analyze the influencing factors (6). Allison C. Yoh, Peter J. Haas, and Brian D. Taylor(2003) documents the approaches deemed by agency managers to be most successful in the face of dynamic environments and transit's declining share of travel(7). Center for Urban Transportation Research (2007) analyzed the NHTS data and reaffirmed the significance of access to the mode choice decision (9).

There has been quite many analyses on the influential items of the transit ridership, most of which involves constructing mathematics models and then examining the accuracy of the models with case examples. The mathematic analysis is advantageous in determining the relevancy of the items and the model building, and is persuasive. However, it is not likely to take full account of features that cannot be quantitatively analyzed. Part of the features, such as people's religious beliefs and travelling patterns, are difficult to be quantified. The city layout is another factor that complicates people's travelling pattern. The analysis of models conducted by previous researchers is for a specific city, not universal.

Given the existence of the city variety, this study considers analysis of the current situation, instead of building an accurate model. The authors use the GDP per capita to represent the economy development of a city, and here it is the comprehensive indicator of the investment made to public transit. To a certain extent, it reflexes the socioeconomic level of a city (external factor), and it considers the population of the city (external factor), and it can reflect the investment ability to public transit, so it is a highly comprehensive indicator. When looking for trends of public transit development, the points in figures are relatively scattered, because that many other factors varies in different cities, so the fitting "bandwidth" is relatively wide.

2. Explanations Notes on Main Indicators

Nomenclature

TL	Total length of public transit line
l_i	Length of line i in operation
l_i^u	Mileage of line i from the upward starting point to the end point;
l_i^d	Mileage line i from the downward starting point to the end point;
l_i^{ud}	Mileage of double back from the upward and downward end point;
n	The total number of lines in operation
TLN	Total length of public transit network;
$\sum_{i=1}^{m} l_i$	Repeat length of the lines;
m	The total number of repeated lines.

Urban Public Transit in this paper means the general term of economic and convenient mode of transport, including buses, trams, rail transit (subway, light rail, tram, maglev, etc.). It is noteworthy that the public transit in this article does not include the taxi and the school bus.

Total Length of Public Transit Lines (TL) means the sum length of all lines in operation. It is calculated with the formula:

$$\mathrm{TL} = \sum_{i=1}^{n} l_i = \sum_{i=1}^{n} \frac{1}{2}(l_i^u + l_i^d + l_i^{ud})$$

Total Length of Public Transit Network (TLN) means the net length of public transit routes in operation. It is calculated with the formula:

$$\mathrm{TLN} = \mathrm{TL} - \sum_{i=1}^{m} l_i$$

Mode share for public transit means within the reference period (2010), the amount of trips made by the residents through public transit (including bus, rapid bus transit and rail transit, does not include taxi, school bus) sharing ratio of the total travel amount (excluding walking). (The data from Wuhan are from 2011)

Mode share for public transit = total amount of public transit trips/total amount of trips×100%

Density of the Public Transit Line Network: The indicator can be used to examine the allocation of the public transit line network, and the accessibility to the public transit for residents. The indicator can reflex the overall development level of the public transit in a city. The high value of the indicator indicates that the large coverage area of the public transit which provides convenience for people to get public transit.

The Coverage Rate of the 300-Meter around Bus Stop: the comparison between the coverage of bus transit (the total size of all circles with the physical center of each bus stop as the center and the service radius as the radius. The overlapped areas are counted for once only) and the size of the urban area.

3. Status Quo Analysis for Major Cities in China

Most major cities in China have been allocating significant investment on road infrastructure. Until recent, many city governments started to realize that more investments on public transit system should be more necessary. However, there were few literatures analyzing the characters of public transit developing in China. The following would conduct a general analysis on the urban public transit in China to assist Chinese central government and Chinese major cities to understand development features. The authors led great efforts on collecting statistic and economy data, geography and population data, transportation infrastructure and operation data, transit passenger degree of satisfaction data, etc. Most of the data is collected from the China Statistical Yearbook (2010).

3.1. Investment on public transit

In this part the authors mainly compared the investments of a few cities in China. We consider public transit network and fleet size as the investment in public transit. The public transit network includes both urban bus network and urban rail network. When assessing the transit network size, it is necessary to consider the significant difference of capacities between rail and bus services. In order to combine all these factors, a generalized network length is proposed to represent the investment, with kilometer as the unit.

Nomenclature

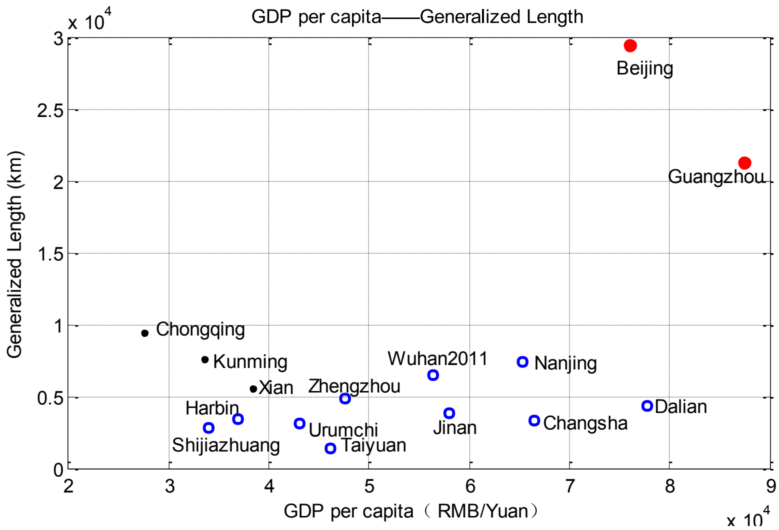
L	the generalized network length (km);
L_{bus}	the net length of bus transit (km);
BO	bus ownership (unit per ten thousand persons);
L_{bus}	the net length of bus network (km);
N_{bus}	the fleet size for bus vehicles (per ten thousand persons);
$\bar{N}_{bus}$	the average of fleet size for bus vehicles, 14.5 among all the selected cities (per ten thousand persons);
L_{rail}	the net length of rail transit (km);
V_{rail}	the daily passenger volume for rail transit (in 10 thousands);
V_{bus}	the daily passenger volume for bus transit (in 10 thousands).

$$L = L_{bus} \times \frac{N_{bus}}{\bar{N}_{bus}} + L_{rail} \times \frac{V_{rail} / L_{rail}}{V_{bus} / L_{bus}}$$

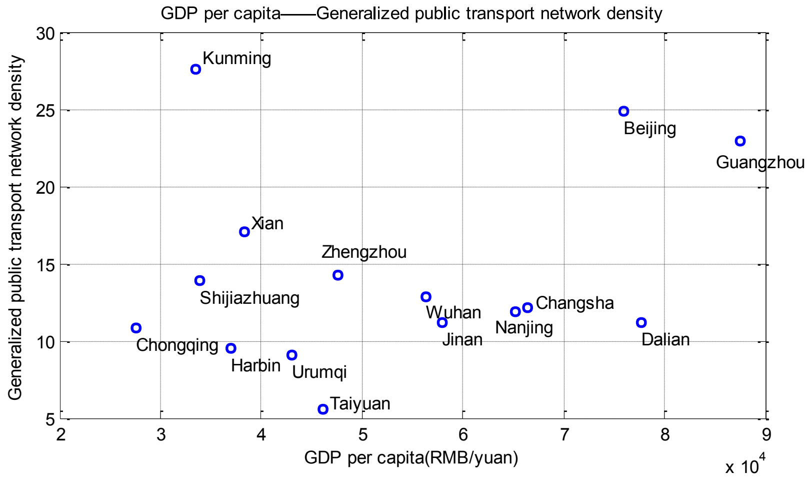
Table 1 below presents the generalized length of public transit and GDP per capita among 14 major Chinese cities. And figure 1 (a) and (b) shows the relationship between the GDP per capita and the Generalized Network Length and Density in some of the cities.

Table 1. Investment on public transit

	Net length of bus Transit (km)	Bus Transit Passenger Volume per day (in 10 thousands)	Bus Ownership (unit per ten thousand persons)	Net Length of Rail Transit (km)	Rail Transit Passenger Volume per day (in 10 thousands)	Generalized Length(km)	GDP per capita (yuan)	City size (km2)	Mode share (%) (without pedestrian)
Beijing	18743	505144	17.50	336	184645	29472	75943	1186	40.1
Changsha	3173	72222	15.05	0	0	3293	66464	272	32.8
Chongqing	11183	161932	11.80	17	4576	9417	27596	870	33.4
Dalian	3090	103107	20.40	0	0	4347	77704	390	45.0
Guangzhou	11547	177074	17.00	236	118102	21239	87458	925	43.0
Harbin	3766	109078	13.10	0	0	3402	36951	359	35.8
Jinan	3681	84872	15.23	0	0	3866	57947	347	29.7
Kunming	8658	90626	12.70	0	0	7583	33549	275	38.0
Nanjing	6907	103691	12.50	85	21459	7384	65273	619	31.0
Shijiazhuang	2405	51266	17.00	0	0	2820	33951	203	27.2
Urumqi	3515	73490	12.80	0	0	3103	43039	343	53.0
Wuhan	5793	153504	16.10	0	0	6432	56367	500	40.0
Xi'an	5531	165387	14.65	0	0	5588	38343	327	41.0
Zhengzhou	4434	83049	16.00	0	0	4893	47608	343	46.4



(a) GDP per capita and Generalized Network Length



(b) GDP per capita and the generalized length density

Fig. 1. GDP per capita and Generalized Network Length and density

As shown in figure 1 (a), it seems that there is not a definite pattern of the interaction between the GDP per capita and the investment made to public transit. For example, the GDPs per capita in Chongqing, Kunming, and Xi'an are relatively low, while the investments in these cities are above average. As the capital city, Beijing has the severest congestion problems in China. To mitigate congestion and to improve the traffic situation, Beijing has made the highest investment to the public transit throughout China. Both Beijing and Guangzhou are the metropolitans with high GDP. They have both made heavy investment to the public transit. The public transit systems in these two cities are relatively far more advanced; the generalized length of the public transit can be twice or even triple of some other major cities in China. In Figure 1, the generalized network lengths within the circle are largely concentrated in the range of 3000 km to 7000 km, while the GDPs per capita are from 40,000 to 70,000 Yuan. It concludes that many medium-economy-level cities are expanding investments in their transit network with growing economy level. Most medium-economy cities have no developed public transit system, the investment on it need to be raised and mega polis such as Beijing and Guangzhou should invest more in transit for the super traffic demand.

The above investment expressed in generalized network length of the public transit represents the absolute value of the investment. Figure 1 (b) considers the land size of the urban area to show the current density of the generalized network length. The generalized network length density considers the land size of the urban area, and it is a kind of relative value, more suitable for comparisons among various cities.

It can be seen from Figure 1 (b) that the investment to the public transit of Kunming is significantly high, showing that Kunming pays more attention to the development of public transit. Beijing and Guangzhou have also made heavy investments, but the generalized network length densities of the public transit in these two cities are smaller than that of Kunming, as their urban built-up areas are more concentrated than that of Kunming. The generalized network length densities of the public transit network in most of the other cities are between 10 and 17km/km^2. However, the figure only shows the investment made to the generalized public transit line network which cannot accurately represent the absolute fund invested to the urban public transit, where the invested funds of Beijing and Guangzhou are much larger than that of Kunming. The figure also shows that there is little relationship between the economic status of the cities and the investment the cities make to public transit. In China, local government plays a major role in public transit development. For example, Kunming government realizes the traffic pressure in advance and has decided to prioritize the public transit development. Although GDP per capita is not high, its investment to public transit is high, which ensures that the city has a more efficient transport system in the future.

3.2. Investment efficiency of public transit

Transit ridership and transit mode share are the most important indicators measuring the efficiency of urban public transit. There are many factors having impacts on the two indicators. People choose their travel modes depending on many factors. In the aspect of travel demand, the factors include income, private car ownership, distribution of city sectors, topography of the city, and so on. In the aspect of public transit supply, the factors include the length of the transit line, the coverage of the bus stop service, the service level, and so on. And these factors are dependent to each other with certain correlation. For example, the income of the family that owns private cars tends to be higher, the topography of the city and the distribution of the city sectors are interacted. In this section, the author choose public transit model share, GDP per capita, and generalized length density to analyze the investment efficiency of public transit.

Mode Share for Public Transit

Public transit model share represents how the public transportation operates in a city, also it can be an indicator of the result of the transit investment. GDP per capita reflects the income of residents and the ability of investment to public transit system. That is to say, GDP per capita can be considered as an overall indicator. Generalized length density is an indicator of transit supply. Figure 2 shows the correspondences between public transit model share and GDP per capita or generalized length density of 14 cities in China.

As shown in Figure 2 left, most cities' mode shares for public transit are below 50%. Mode share for public transit first increases along with the growth of GDP per capita. Most cities in China do not have their public transit model share more than 50%, which is much more less than that in New York, Singapore and Tokyo (New York 75%, Singapore 63%, and Tokyo 80%). There is a big room to improve public transit model share in China. The authors divided the correspondences of GDP per capita and public transit model share into three phases. In the first phase, with lower socioeconomic development level, public transit always has higher efficiency with the same investment, because there are fewer options for travel with low car ownership. Mode share for public transit in the second phase decreases along with the growth of the GDP per capita. This is mainly because when economic develops to a certain level and traffic congestion is not very prominent, and car industry in China is strongly encouraged by the central government to promote economic development. Rising personal incomes and car ownership results that public transit is struggling to compete with the private automobile. Car ownership has an explosive growth at this stage, the mode share for cars increases. At the third phase the cities' socioeconomic development level is relatively high, and traffic congestion problem highlights. These cities are fully aware of the car traffic pressure, as well as the need for the development of public transit. In order to ease the traffic pressure, various restrictions are implemented, such as license plate roulette in Beijing, car-plate auction in Shanghai, and parking charge etc.; moreover, the investment in public transit is expanded to improve its service. With these restrictions and advocates, the mode share for cars drops and that for public transit rises. This reflects along the cities' development process, the car usage is advocated earlier and limited latter, with the generation of traffic problem and the effort to ease traffic pressure.

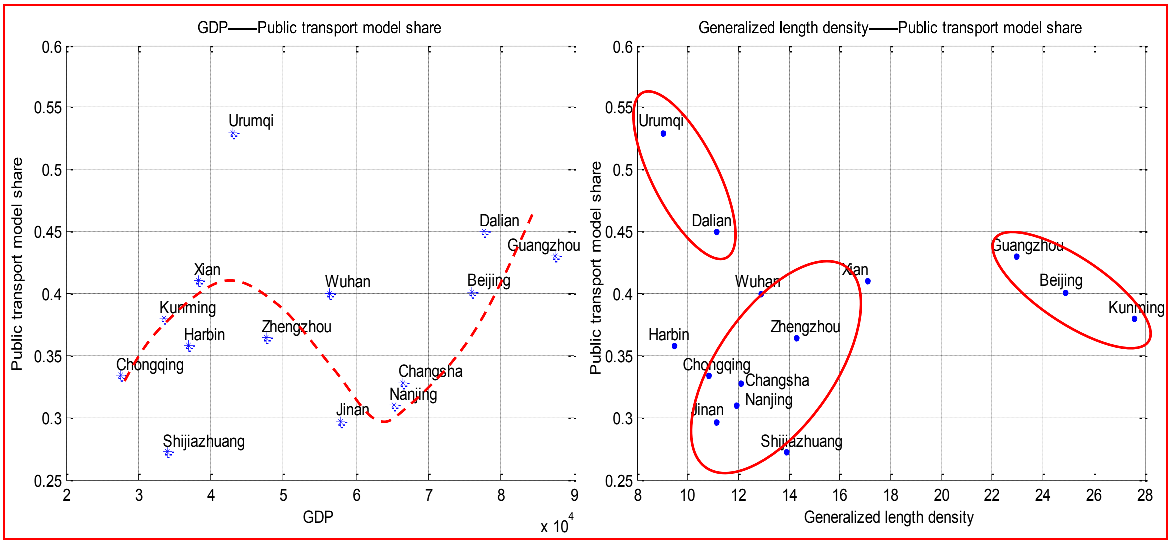


Fig. 2. GDP per capita and generalized length density vs. mode share for public transit

As to the right one of figure 2, the public transit development levels can be divided into three parts. First, some cities, such as Zhengzhou, Changsha, Nanjing, Jinan and Shijiazhuang, have low generalized transit line-length densities and low public transit model shares; second, some cities, such as Guangzhou, Beijing and Kunming, have better generalized transit line-length densities and higher public transit model share; third, there are cities which have lower generalized transit line-length densities with the highest public transit model share, such as Urumqi and Dalian. The first and the second parts are easily to understand, that the public transit model share grows with the generalized transit line-length density. However, the reason for the third part is complex. The most important factors should be the flexibility of selecting means of transport and the urban layout which affects the distribution of traffic demand.

In the future, cities at different stages should learn different experiences to solve problems that occur at similar phases in other cities. In this way, it can avoid some serious problems such as congestion caused by sharp raised private car number. Traffic congestion due to uncontrolled private cars has become a great burden to these cities. Cities in the first phase should focus on the development of public transit in advance to avoid this problem.

In Urumqi the mode share for public transit reached 53.0% with a relatively low level of GDP per capita. Urumqi has a typical strip of urban layout, the built-up area is centralized. The generalized public transit network density in Urumqi is low, however, the built-up areas is the relative concentrate, thus the utilization of public transit network is high and that is to say the investment efficiency of public transit network is high. Cities with strip layout always have strong intensity of traffic demands on main roads, hence, public transit network implemented on these roads will have relatively high efficiency.

3.3. Public transit development

In order to analyze how to develop public transit system with the growth of GDP, this article considers series cities as the development stages of one city, due to the lack of data by time of a single city. This section analyzes the road transit ridership along with the road transit net length. Table 2 (a) shows the public transit development data of major cities. At the end of 2010 in China, the cities which have a certain scale of rail transit are: Beijing, Shanghai, Nanjing, Guangzhou, Shenzhen and Chongqing shown as Table 2 (b).

The authors choose two groups of cities with similar population densities: 1) Hefei, Changsha and Chengdu; and 2) Harbin and Kunming. Table 3(a) shows that passenger volume raises along with the increment of public transit network length. Table 3(b) shows that the public transit network length of Kunming is far longer than that of Harbin. The road public transit network length of Kunming is about twice the length of Harbin. But the passenger of Kunming is not more than that of Harbin, or the passenger numbers are at the same level.

Table 2. Public transit development

2 (a) Bus transit development

City	Bus Transit Network Length (km)	Bus Transit Passenger Volume Per Year(10 Thousand)	GDP per capita (Yuan)	Bus Transit Passenger Volume Per Day(10 Thousand)	Area of Built-up Zone (km2)
Shenyang	3718	119273	62357	327	412
Changsha	3173	72222	66464	198	272
Hohhot	1556	44805	65517	123	166
Jinan	3681	84872	57947	233	347
Chengdu	5953	121538	41253	333	456
Changchun	4371	64721	43936	177	394
Zhengzhou	4434	83047	47608	228	343
Taiyuan	2529	42879	46144	117	245
Hefei	1856	60873	48312	167	326
Nanchang	3371	53918	43961	148	208
Fuzhou	2502	95394	44000	261	220
Yinchuan	1076	18171	42771	50	121
Urumqi	3515	73490	43039	201	343
Harbin	3766	109078	36951	299	359
Shijiazhuang	2504	51266	33915	140	203
Lanzhou	1084	60907	30672	167	196
Kunming	8658	90262	33549	247	275
Haikou	2426	23032	38731	63	98
Xining	982	38594	28428	106	67
Guiyang	2612	59551	26209	163	162
Nanning	2336	63598	26330	174	215
Shenzhen	16987	194246	94296	532	830
Chongqing	11183	161932	27596	444	870
Guangzhou	11547	177074	87945	485	925
Beijing	18743	505144	75943	1384	1186
Shanghai	23130	280758	76074	769	866
Nanjing	6907	103691	65273	284	619

Wuhan	5793	153504	56367	421	500

2 (b) Rail transit development

City	Beijing	Shanghai	Guangzhou	Nanjing	Shenzhen	Chongqing
Rail transit Line Length (km)	336	453	236	85	64	17
Rail transit Passenger Volume Per Year (10 thousand)	184645	188407	118102	21459	16271	4576

Table 3. Two groups of cities

Table 3 (a) Hefei Chongqing and Changsha

	Bus Transit Passenger Volume Per Day(10 Thousand)	Bus Transit Network Length (km)	The population density
Hefei	167	1856	2569.5
Changsha	198	3173	2520.6
Chengdu	333	5953	2513.6

Table 3 (b) Harbin and Kunming

	Bus Transit Passenger Volume Per Day(10 Thousand)	Bus Transit Network Length (km)	The population density
Harbin	299	3766	655.8
Kunming	247	8658	643.0

The comparison of Harbin and Kunming illustrates the growth of public transit network length might not be the only reason to improve ridership. Kunming could probably diversify its investment on general public transit, e.g. metro, tram, bicycles.

Figure 3 shows the development level of public transit in most cities of China. There is an obvious jump between the dotted line and solid line at Wuhan point. Wuhan has an urban population density: 1915.56 person/km^2, less than Chengdu's 2513.62 person/km^2, these two cities have similar length density of public transit network, but Wuhan has more passenger volume for Wuhan has built a certain scale rail transit. This may indicate implementation of rail transit is helpful to increase the attractiveness of bus transit, because if the rail transit service level has been improved, the trust of public transit will increase. Generally, the passenger volume rises along with the incensement of generalized network length, and with each additional unit of public transit generalized network length. The increase in passenger volume is relatively stable; city scale expands at the same time. With a certain city size, when the public transit network length is long enough, additional road transit network length will not change transit ridership significantly. In other words, the increment of investment in network has certain effect on transit ridership but with limitation of urban land resources and bus capacity. Such investment might not be efficient. Under such circumstance, in order to increase transit ridership, public transit should no longer have a single model of buses, but should develop rail traffic. Especially to the city with over 100 million populations, metro is a common solution.

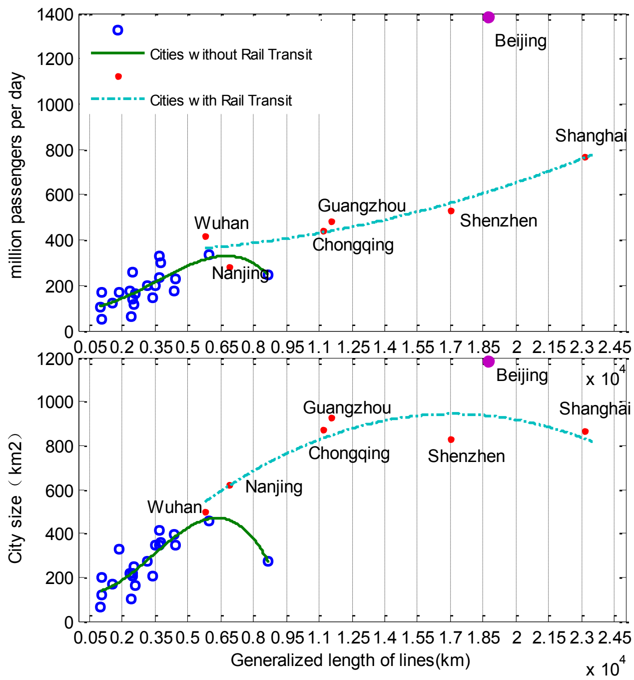


Fig. 3. Public transit developments

4. Suggestions towards Transit Metropolis

Cities in the first phase should focus on the construction of public transit, in order to reduce the urban traffic pressure caused by low sharing rate of public transit. Because of capital shortage in this phase and small city scale, so it is not suitable for the development of metro and other large-capacity rail transit. Investment in regular public transit should be increased. But it should be noted when the road public transit length is long enough, the increase of investment in network might not have significant effect on transit ridership. In the cities where traffic is seriously congested, effective measures should be taken to restrain the development of private cars, meanwhile investment in public transit should be raised to improve service level to enhance its attractiveness.

When the economic strength reaches a certain level, the implementation of rail transit should be considered. Cities, with a population of over one million, typically require the construction of subway, rail transit, BRT and bicycle systems, forming a hierarchical multi-modal public transit system. According to the successful experiences from Wuhan and Hangzhou in China, it is recommended to develop public bicycle sharing system to solve the last-mile problem of public transit. According to the survey, 44 % of Beijing's private car travel distance is shorter than five kilometers, private car has short distance travels is a prominent problem. Incorporating shared bicycle system into the city's public transit system to solve the last-mile problem and enhance the attractiveness of public transit, at the same time provide more choices for residents in short distance travel.

5. Conclusions

GDP per capita belongs to external factors and internal factors of influencing the ridership of public transit. This article mainly analyzes GDP per capita, and joined the main single factor analysis of the impact on the development status of China's urban public transit. There is not a definite pattern of the interaction between the GDP per capita and the investment made to the public transit. The investment of most medium-economy-level cities in China is expanding with the growing economy level. Both Beijing and Guangzhou are large metropolitans with the economy highly developed. They have both made heavy investment to the public transit. There is no obvious relationship between the economic status of the cities and the investment the cities make to public transit. The city's public transit development highly depends on the decisions from local government.

Most cities' public transit model shares are below 50%. Public transit model share first increases along with the growth of per capita GDP, and then decreases along with the growth of per capita GDP, and then the public transit sharing rate increases along with the growth of per capita again. So the city development can be divided into three phases. In the first phase, with lower socioeconomic development level, public transit always has higher efficiency with the same investment. Public transit model share in the second phase decreases along with the growth of the GDP per capita. At the third phase the cities' socioeconomic development level is relatively high, and traffic congestion problem highlights. These cities are fully aware of the car traffic pressure, as well as the need for the development of public transit. It is not always most efficient to increase the public transit network length. A hierarchical and efficient multi-modal system with smooth transfers and good coverage is always efficient to mitigate traffic congestion and improve the sustainability of urban transportation system.

The "Transit Metropolis" project demonstrates the determination from the Ministry of Transport in China to mitigate the ever-worst traffic congestion and pollution issue. The authors will continue to utilize the data collected from the several major cities to assist the policy making, transit network planning, network optimization, and system evaluation.

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